Space Weather Technical Forecast

Issued on Saturday, 22 April 2023 at 01:46 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G3 from CME Likely Monday 24 April. Else Chance of R1/R2 radio blackouts throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity rose to Moderate in the UTC day of Friday 21 April, with a late M1.7 at 21/1812UTC on an otherwise smooth declining X-ray flux trend from C into B-class recorded at GOES16. The peak flare emanated from a large centre-disc flare and filament eruption combination, with one end of this filament formerly anchored in the vicinity of AR3283 - an otherwise unassuming Bxo/Beta. An associated Type IV radio signature was observed at 21/1759UTC, and a small EUV wave was seen centred on AR3283.

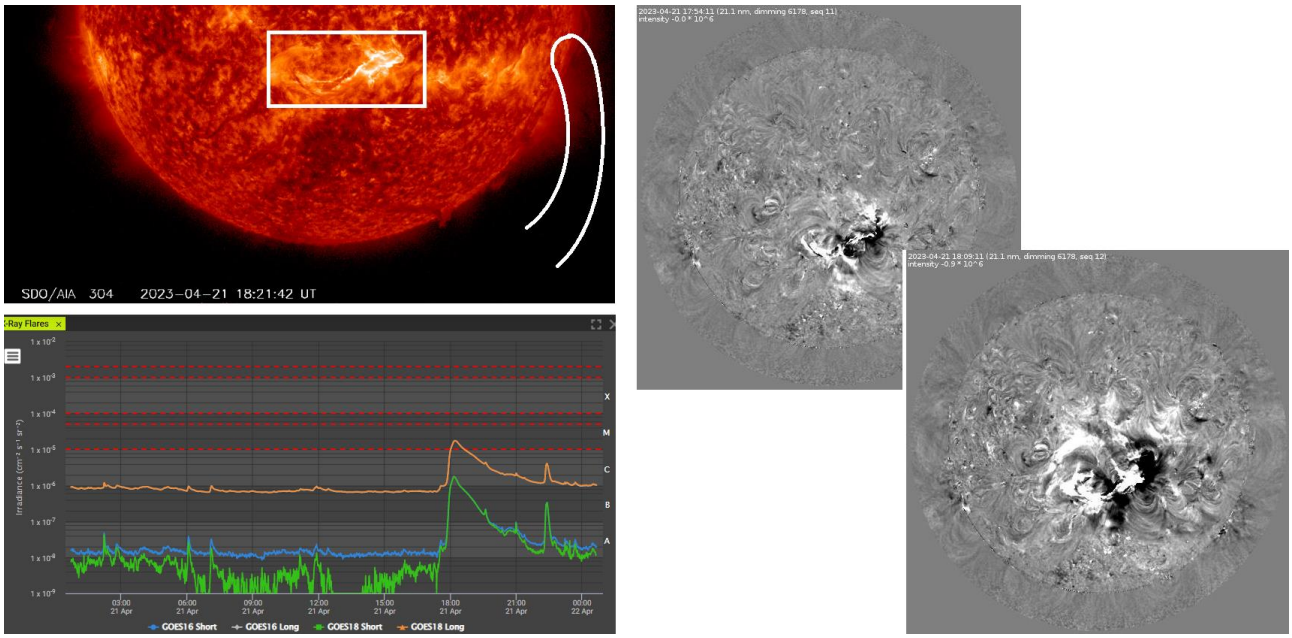

Figure 0: Clockwise from top left: AIA304 imagery showing aftermath of 21/1812UTC filament eruption and M1.7 flare (boxed), with the main ejecta showing as the arced absorbing region far right; time-integrated AIA211 dimming of the event, processing courtesy SIDC ROB; and GOES16 and 18 X-ray flux showing the event.

The filament in question formed part of a longer feature that spanned near 20 degrees solar longitude, and although much of this was significantly disturbed, the eastern portion at least appears to have remained in place on the Sun. The resulting Coronal Mass Ejection (CME) was clearly visible in many wavelengths in subsequent satellite imagery, eventually manifesting on coronagraphs later in the UTC evening as an apparently twin-lobed shock forming an 'infinity'-shaped symbol centred just west of centre-disc. The bulk of ejecta was apparently directed south and west of the Sun-Earth line, with the CME occluding the southwestern solar horizon corona in AIA304 between 1815 and 1830UTC.

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The above region was one of up to five on the current solar disc, with AR3279 now no longer distinct in the southwestern quadrant, but potentially replaced by an unnumbered arriving Dso/Beta near the southeastern limb. All of the numbered sunspot groups on the Earth-facing side were either stable or in decay, including the largest - AR3282 in the northwestern quadrant. This showed apparent areal decay as well as a fading of some of its intermediate spots, while its leading large penumbral spot became more symmetric with time. This finished the 24 hours as an Fhi/Beta.

Other events in coronagraph imagery included a high latitude northwest-directed narrow CME, and a western limb event, however neither is expected to affect Earth. Discussion around a 'ghost' CME from a coronal hole realignment prior to this reporting period is now in all likelihood rendered moot by the 21/1812UTC centre-disc filament.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by ACE at L1, was suggestive of a slow solar wind regime, with the second half of the UTC day characterised by minor SSBCs. The solar wind speed was roughly level in the high 300s of km/s, while the solar wind density was stable in single figures ppcc throughout. The IMF was stable at or below 7nT over the 24 hours, while the north-south component ranged between +/-6nT, being mainly co-aligned with Earth's field prior to 21/1315UTC, and mainly anti-aligned thereafter. The phi angle was negative (towards the Sun) before 21/1015UTC, and more variable subsequently.

The net effect of the above solar wind measures was Quiet to Unsettled, with a provisional peak Kp of '3o' in the 15-18, 18-21, and 21-24UTC periods, likely the result of the SSBCs.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) as measured at GOES16, was at Background levels.

High energy electron flux (greater than 2MeV) as measured at GOES16 was at Normal Background levels. The associated 24-hour electron fluence was well below the Active threshold on a steady trend, with 1.43e6 integrated pfu observed at 22/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity carries a Chance of isolated Moderate activity, mainly due to AR3282 but perhaps also from the new region rotating onto the southeast limb. No regions leave the disc in the period.

Solar Wind / Geomagnetic Activity: The large full-halo CME from the 21/1812UTC M1.7 flare and filament is due to arrive at the start of the UTC day of Monday 24 April. The 15 April filament CME is now overdue and is only likely to manifest as a density enhancement if present given the length of time it has spent in transit. This has suitably moderated any effects expected.

Earth is otherwise in a slow regime at present. There is a chance of either CH94 or CH95 (both negative) affecting Earth in the next 36 hours, with wind speeds perhaps reaching 450-550km/s, although this aspect carries low confidence, and a slow regime could equally persist throughout.
A G3 Major Geomagnetic Storm is considered Likely on Monday 24 April from the 21/1812UTC flare and filament. A G1/G2 is Expected, and there is some bleeding of these probabilities into neighbouring UTC days. Otherwise, there is a Slight Chance of G1 over the current UTC weekend - the result of any surviving 15 April CME material and/or the negative coronal holes.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is most likely to persist at Background levels, although there is a slight chance of S1 or greater, mainly due to AR3282 but also any delayed enhancement from the M1.7 flare in the near-term.

High energy (greater than 2MeV) electron flux is currently at Normal Background levels, with little

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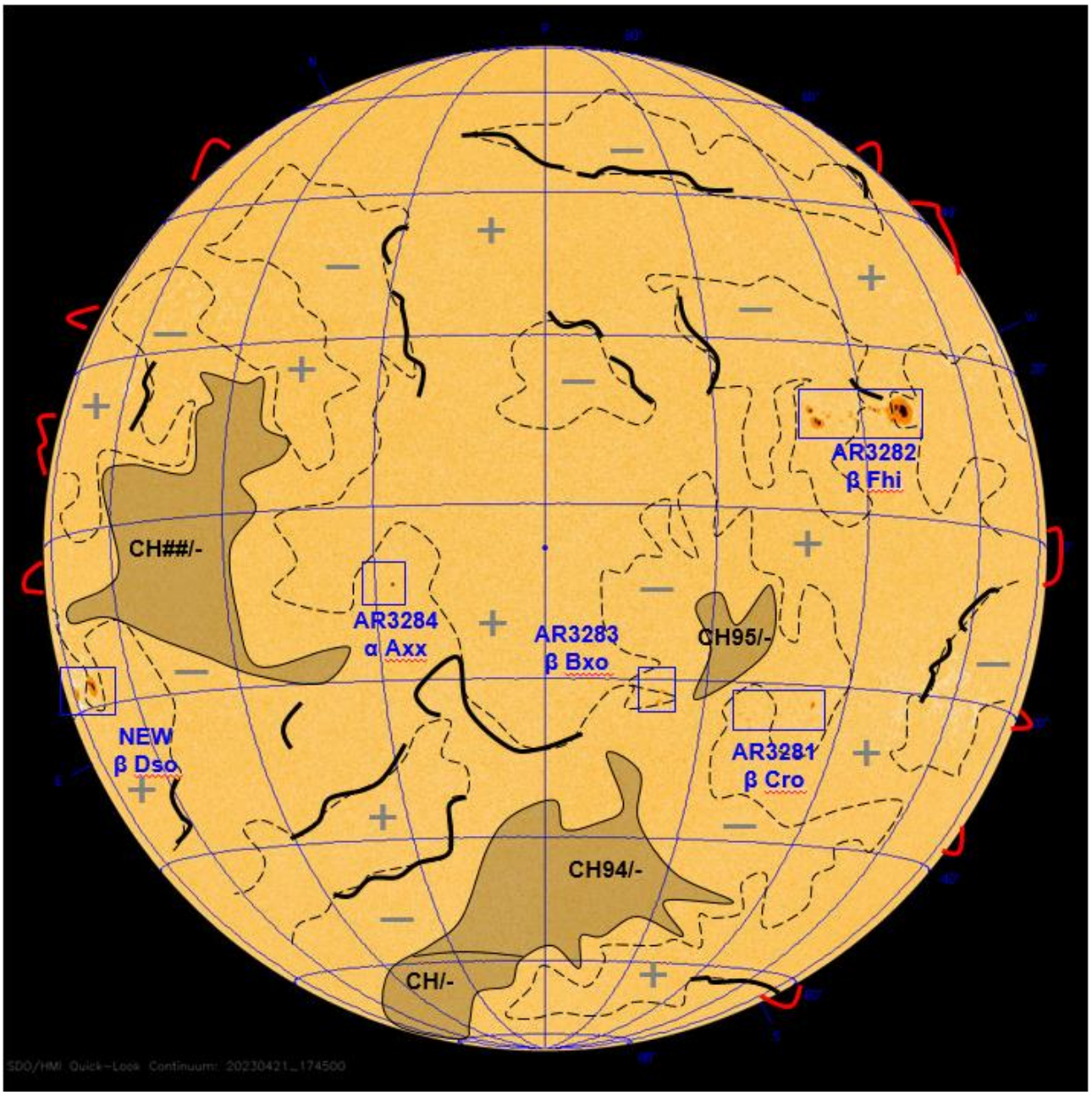
change expected, although a slight increase is possible later in the period in response to HSS effects. The associated 24-hour integrated fluence is expected to remain below the Active threshold (1e8 integrated pfu), but with an increasing trend later in the period.

Figure 1. Solar Analysis Valid 22/1745UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The dominant feature of the four-day forecast is the M1.7 21/1812UTC CME from centre-disc. Available imagery for the event is very good, although the very narrow angular difference between STEREO A and Lasco perspectives obviously introduces error bars into the measurement, as does the fact that the CME ejecta itself is rather complex, with numerous lobes of the shock apparently interacting - especially to the northwest of the Sun-Earth line. The main ejecta from this event has been assumed to be that seen heading narrowly southwest, with the CME's angular width therefore significantly impinging on the Sun-Earth line.

The faint halo CME from a large filament eruption late on 15 April is now only likely to manifest as a density enhancement should it arrive in the first 24-hour period. The current ambient wind is faster than the CME's inferred speed from its lengthy transit time - which would be around 300km/s should it arrive imminently, and only 250km/s by the end of the current UTC day. In all likelihood its chances of delivering significant activity are now greatly reduced and essentially vestigial.

The coronal hole forecast carries higher uncertainty than is typical. Earth is currently sampling a slow solar wind regime. CH94 or CH95 (both negative) may become geoeffective inside the next 36 hours, however this is not supported by MOSWOC Enlil, which favours a continuation of ambient conditions. CH94 is a high latitude feature and may pass below Earth, with this feature also smaller and presumably slower than on the previous rotation. CH95 is more centrally located, but had been obscured by sunspot flux to the south and east of it rendering it invisible for a time, however the M1.7 flare and filament eruption has reopened this feature. Given the transit time of any fast wind to Earth, this latest development is not expected to affect the forecast for Earth. Evidence from late last working week of CH95's stature at that time suggests solar windspeeds may reach 450-550km/s, perhaps giving a Slight Chance of G1.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	10	20	80	30
Strong	G3	No	1	10	60	1
Severe	G4	No	1	1	10	1
Extreme	G5	No	1	1	1	1

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Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
21/2121	Full	Flare/Filament	Centre-west	1081	24/0200UTC	Major geomagnetic storm likely.
16/1343	Full	Filament	NW	342	Imminent or miss	Low confidence

Figure 2: Analysis of 21/1812UTC CME using CAT. Shown is fit to Lasco C3 difference imagery, triangulated using STEREO COR2.

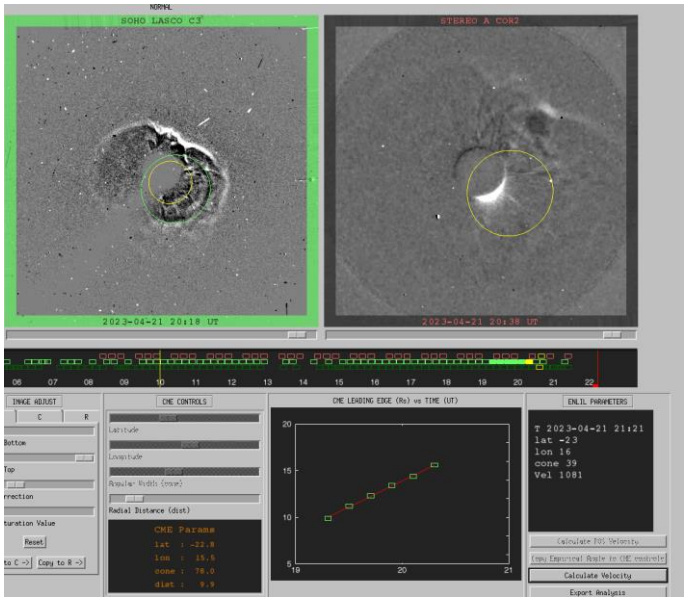
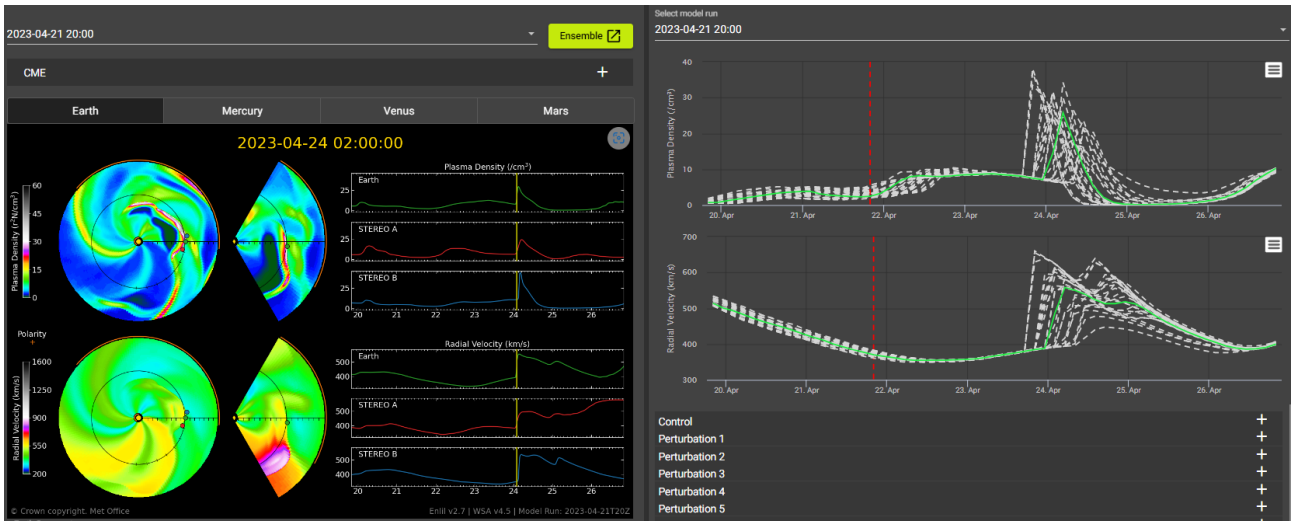


Figure 3: Resulting latest MOSWOC Enlil run and ensemble stopped at the time of arrival of the 21/1812UTC CME.



Radio Blackouts - X-Ray Flares:

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There are now up to five sunspot regions on the visible disc, with the largest and nominally most threatening AR3282 upstaged by the apparently unassuming AR3283 near centre-disc. This region appeared as a simple Bxo/Beta upon delivering an M1.7 flare at 21/1812UTC, perhaps driven by sub-'surface' structures or its close associated with a large filament to its east. Activity from this spot group may prove to be an exception, with the X-ray trace at GOES16 otherwise quiet and declining, and with all numbered front-sided groups stable or else in decay, including the largest.

None of the front sided groups leave the disc in the period, and at present there is no strong evidence for large eastern solar horizon arrivals, so a flat Chance of M-class flares is proposed throughout the coming four-day period.

X Ray Flares	**Level**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability			**(%)**	**(%)**	**(%)**	**(%)**
Active	**R1-R2 M Class**	Yes	30	30	30	30
Very Active	**R3 to R5 X Class**	No	1	1	1	1

Solar Radiation Storms - (High Energy Protons):

High energy proton flux (greater than 10MeV), as observed by GOES16, is currently at Background levels. At the time of writing there does not appear to have been any response in the proton spectrum at GOES16 to the M1.7 flare from near AR3283, however there is a slightly raised chance on day one should this arrive - with this imminent if present. There may be a slight response recorded in lower energies at ACE EPAM LEMS, although there may be other reasons for this (noise or perhaps even the 15 April CME).

There is otherwise a daily Slight Chance of an increase to S1 or greater, should any larger flares occur, with this still thought most likely from AR3282.

Radiation Storms	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ S1**	No	10	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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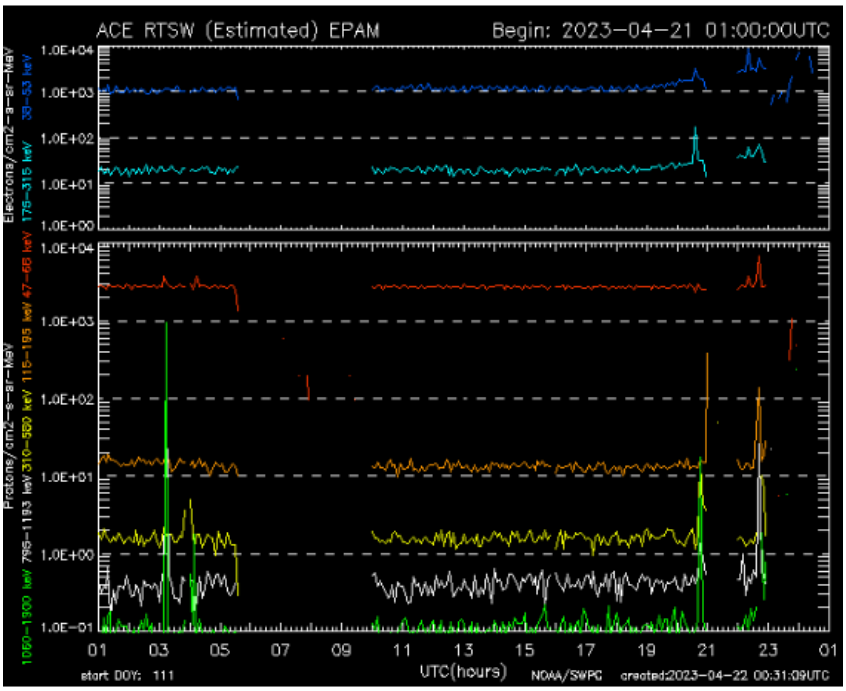
Figure 4: ACE EPAM LEMS, showing possible slight reaction to the 21/1812UTC M1.7 flare in low energies.



High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2MeV) electron flux is currently at Normal Background levels. The most likely drivers of any change to this state of affairs are the twin negative coronal holes CH94/- and CH95/-, however MOSWOC Enlil does not currently support either becoming geoeffective. Should persistence methods prove accurate, a 450-550km/s fast wind may be expected, however even this would likely be marginal for electron flux to breach the diurnal High threshold.

The chances of 24-hour integrated electron fluence breaching Active are considered Slight in the period, probably reaching a new equilibrium into the new UTC working week, with the caveat that the driving coronal hole fast winds and possibly interrupting CME(s) are all low confidence.

GEO Electron Environment	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	10	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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